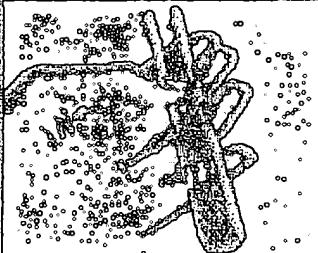
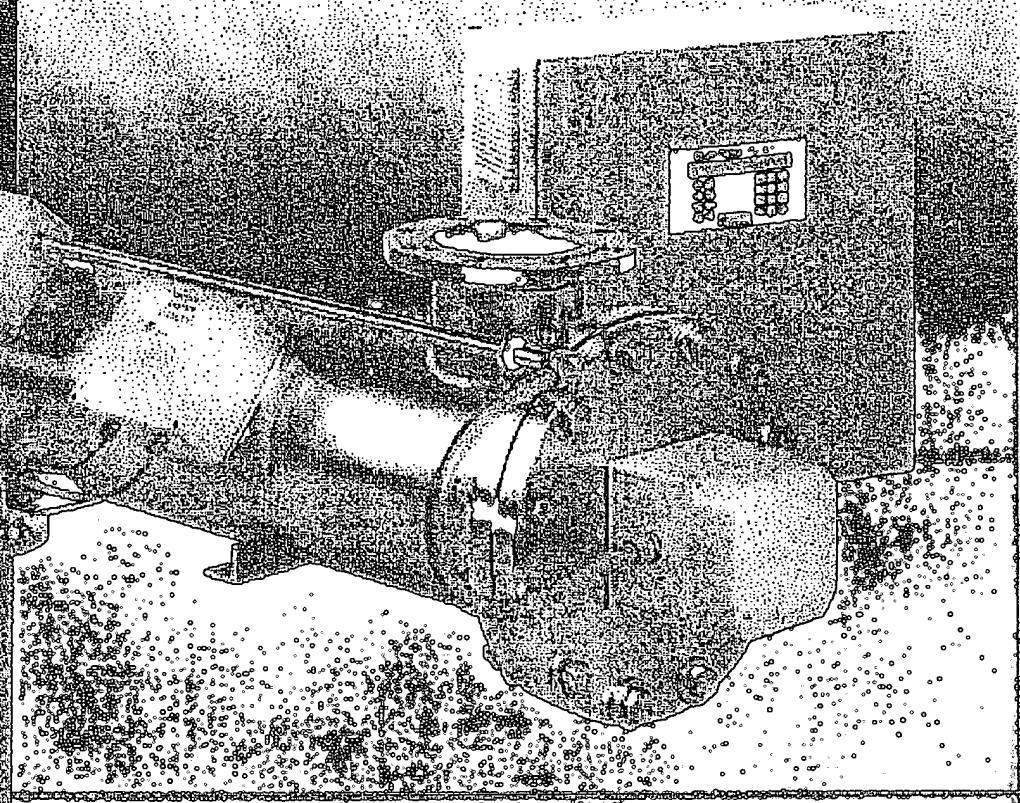


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TROJAN SYSTEM

UV 5000™

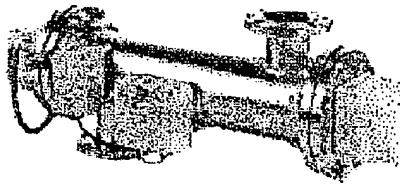


Trojan Technologies Inc.

Ultrapure Water

Ultraviolet Systems

REVOLUTIONARY UV TECHNOLOGY FOR ULTRAPURE WATER



Evolution of UV Light Technology

For over 60 years, ultraviolet (UV) light has been used as a practical and cost-effective method to disinfect many types of liquids.

More recently, UV technology has also been used to destroy residual ozone in the pharmaceutical and beverage industries, where ozone is often utilized to disinfect and oxidize trace organics. Residual ozone is destroyed because it negatively impacts the quality of finished products.

UV lamps emitting light energy in the wavelength regions lower than 220 nm have been found to be effective in reducing total organic carbon (TOC) levels in water and are used extensively in ultrapure water treatment for the semiconductor industry. Reduction of trace organic levels in ultrapure water is critical to product yield and overall water treatment system performance.

Applying UV Energy in Liquid Applications

Specific amounts of UV energy (applied UV dose) are required to effectively destroy micro-organisms, break apart TOC compounds or eliminate ozone residuals.

Applied UV dose is measured as the product of UV light intensity times the exposure time within the UV lamp array.

(A) Disinfection

Micro-organisms vary in their sensitivity to UV energy. Lethal doses for various micro-organisms are known and well documented, as shown in the chart below.

Many of these organisms are destroyed with minimal amounts of UV energy (in most cases, less than 20,000 $\mu\text{watt-s/cm}^2$). All Trojan UV8000 low and medium pressure lamp UV systems are designed to provide UV doses in excess of 30,000 $\mu\text{watt-s/cm}^2$ at the end of lamp life to ensure minimum reductions of 99.9%.

(B) Ozone Destruction

Reduction of residual ozone is accomplished at the UV wavelength of 253.7 nanometers (nm). Ozone, when exposed to UV light, reaches an excited state more rapidly and is consumed to leave only the oxygen molecule dissolved in the water. Effective dissociation of up to 1 part per million (ppm) of residual ozone can be achieved with an applied UV dose of 90,000 $\mu\text{watt-s/cm}^2$.

Ultraviolet Dose Required for 99.9% Inactivation of Various Micro-organisms ($\mu\text{watt-s/cm}^2$)*

Bacteria	UV Dose	Virus	UV Dose
Bacillus anilibradicis	13,500	Adenovirus Type 3	7,400
Bacillus megatherium (veg.)	3,600	Bacteriophage	10,800
Bacillus megatherium (spore)	8,100	Coxsackie AZ	9,500
Bacillus subtilis (mixed veg. & spore)	18,300	Hepatitis A	21,900
Clostridium tetani	36,000	Influenza virus	10,800
Corynebacterium diphtheriae	10,200	Poliiovirus	9,600
Escherichia coli	6,300	Rotavirus	28,500
Leptospiro	8,600	Tobacco Mosaic virus	720,000
Microboccus candidus	10,200		
Microboccus radiodurans	18,000		
Microboccus sphaeroides	61,500	Yeast	
Mycobacterium tuberculosis	30,000	Baker's yeast	14,400
Neisseria catarrhalis	17,400	Brewer's yeast	11,700
Phytomonas tumefaciens	13,200	Common yeast Cake	21,900
Proteus vulgaris	13,200	Saccharomyces cerevisiae	21,900
Pseudomonas aeruginosa	7,800	Saccharomyces ellipsoides	21,900
Pseudomonas fluorescens	18,500	Saccharomyces sp.	29,100
Salmonella	10,500		
Salmonella enteritidis	18,200		
Salmonella enteritidis	12,000	Mould Spores	
Salmonella paratyphi	9,600	Aspergillus flavus	171,000
Salmonella typhi	8,300	Aspergillus flavus	158,000
Sarcina lutea	59,100	Aspergillus niger	468,000
Serratia marcescens	7,200	Aspergillus oryzae	17,900
Shigella dysenteriae	6,600	Aspergillus penicillatus	138,000
Shigella flexneri	5,100	Penicillium digitatum	39,000
Shigella paratyphi	6,100	Penicillium expansum	43,600
Spirillum rubrum	13,200		
Staphylococcus albus	9,900		
Staphylococcus aureus	15,000	Protozoa	
Streptococcus hemolyticus	6,600	Chlorella Vulgaris	34,700
Streptococcus lactis	18,600	Nematode eggs	147,000
Streptococcus pyogenes	6,600	Paramecium	315,000
Streptococcus viridans	6,000		
Vibrio comma	7,200		

*This table indicates the dose ($\mu\text{watt-s/cm}^2$) of UV required for a 3 log reduction of various microbes. The doses have been calculated from 1 log reduction values contained from several sources as reported by various authors. Any variations in the UV doses displayed compared to other published data may result from different experimental approaches, calibration procedures, etc.

(C) TOC Reduction

Total organic carbon (TOC) reduction with UV energy is more complex than inactivation of microbes or destruction of residual ozone. There are different mechanisms at work, dependent on the type of UV lamp used.

Where 185 nm low pressure UV lamp systems are used, the working mechanism is the direct photolysis of water. This process creates powerful hydroxyl (OH^-) radicals that attack organic compounds and break them into acid-based groups which can readily be absorbed by ion exchange systems. If complete oxidation occurs, CO_2 and H_2O are the final products. This mechanism functions in a thin water layer due to the poor transmission of short wavelengths in water.

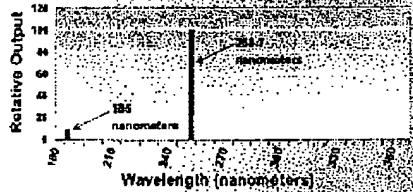
Where broad spectrum medium pressure UV lamp systems are used, two mechanisms are at work. The lower wavelength emissions (below 220 nm), create hydroxyl radicals. Direct

photolysis of the organic contaminants also occurs as a result of the longer wavelengths emitted by the medium pressure UV lamp. These longer wavelengths can be effective for organic compounds that have a UV absorption maximum higher than 220 nm. Since longer wavelengths are more readily transmitted, this second mechanism will function well at distances from the lamp which are greater than those used for the direct photolysis of water. In this regard, the medium pressure lamp is often considered to be a better choice for this unit operation in a high purity water application.

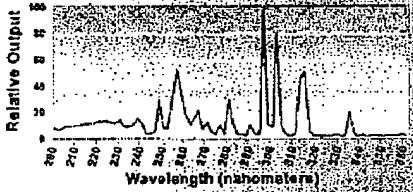
Generally, high applied UV doses are required to break apart organic bonds. UV doses start as low as 90,000 $\mu\text{watt-s/cm}^2$ and can exceed 300,000 $\mu\text{watt-s/cm}^2$ depending on the type and level of organic to be treated. In order to assess your requirements, contact Trojan for assistance in designing the appropriate UV system for your TOC reduction application.

UV Lamps

All Trojan UV lamps are manufactured and quality inspected to our engineered specifications. Trojan specifies to its lamp suppliers the materials, dimensions, electrical and UV output qualities that are acceptable for use in its UV systems.

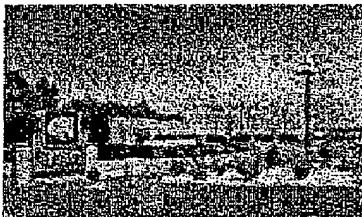
Low Pressure UV Lamp Output

Trojan low pressure UV lamps have output peaks at either 253.7 nm for disinfection and ozone destruction capabilities or 185 nm for the reduction of TOC in high purity waters. Trojan medium pressure UV lamps emit a broad spectral output, in the range of 200-400 nm, with peaks of energy fine-tuned for maximum output efficiency so that disinfection, ozone destruction and TOC reduction can be obtained with one lamp.

Medium Pressure UV Lamp Output

All Trojan UV lamps have uniquely designed, single ended electrical connections complete with a dielectric barrier between pins to ensure a high degree of electrical integrity and safety.

The single ended lamp design allows many Trojan UV systems to be serviced from one end of the installed vessel, at working height. Eliminating half the electrical and water sealing connections reduces the required maintenance time compared to most other manufactured UV systems.

**Trojan: The Company and Its UV Technology Philosophy**

Trojan Technologies Inc. has worked diligently to provide sound UV technology to our valued customers for over 20 years. Industries have trusted our designs for quality, reliability and consistent performance. Our fully equipped research facilities, complete with microbiological and chemical laboratories, have developed scientifically based UV

technology solutions which exceed today's requirements and discover tomorrow's opportunities.

Our engineering staff create the most cost-effective designs through sound engineering practices, based on scientific research and high-quality standards.

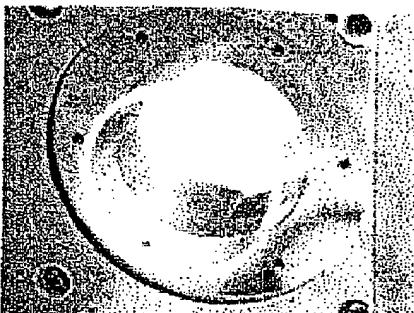
To complement our research and engineering activities, Trojan's sales and marketing team provides consistent customer contact and after-sales service, second to none. Our three strategic warehouse and office locations, along with a committed distributor network, provide efficient and timely service to a growing global market. Replacement parts and technical services are only a telephone call away.

Your UV needs are our first priority.

TROJAN SYSTEM UV8000

Quartz Sleeves

All UV lamps in Trojan systems are protected by fused quartz sleeves, designed to allow maximum emission (greater than 95%) of the available UV energy from the lamps.

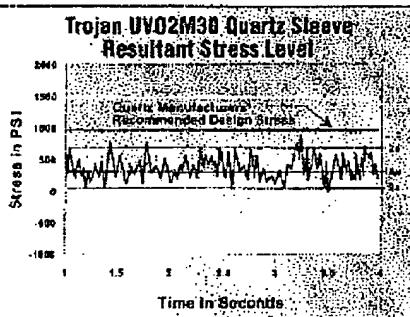


UV8000™ strain tested quartz sleeve

Trojan medium pressure UV lamp systems utilize strain tested quartz sleeves, available in natural or ozone free materials. Natural quartz materials are used in non-critical areas of the ultrapure water system. Ozone free quartz is used in critical disinfection locations such as semiconductor

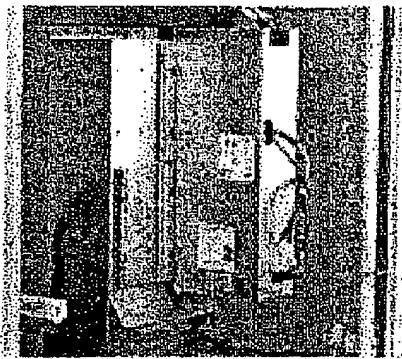
polish loops to prevent the oxidation wavelengths from passing into the ultrapure water. The use of ozone free quartz in these critical areas reduces the potential for oxidation of trace organics present, which ensures the resistivity of the water does not fall below acceptable values.

The strain testing, conducted by an independent testing laboratory, has concluded that the quartz sleeve materials used in Trojan medium pressure lamp UV8000 systems possess a high degree of strength. Our designs can tolerate higher flowrates without the threat of breakage due to hydraulic stresses imparted by flow patterns into and through our medium pressure UV systems.



Power Supplies

In maintaining our commitment to developing leading edge UV technologies, Trojan scientists and engineers have developed more efficient electronic power supplies. These electronic



Space-saving, efficient System UV8000™ variable Input electronic ballast

ballasts provide stable UV lamp input power resulting in elevated levels of UV energy from the lamps within our low pressure lamp UV8000 systems. Trojan systems provide higher applied UV doses when compared to other similar sized systems in the market. Use of such highly efficient electronic ballasts also reduces requirements for cooling in control panels.

Trojan has also pioneered the development of a notebook computer sized electronic power supply for its medium pressure lamp UV8000 systems. Cumbersome panels and heavy, outdated transformer/capacitor technology are replaced by a fully variable input, high frequency power supply found only in Trojan medium pressure lamp UV8000 systems. A significant advancement in this electronic power supply is its ability to automatically increase or decrease the UV output from the lamp according to conditions of lamp age or flow, in any specific application.

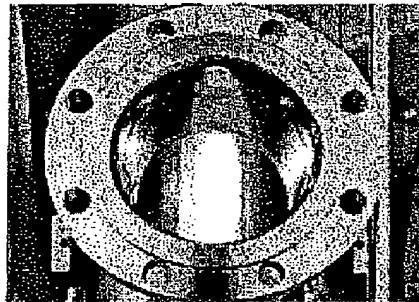
TROJAN SYSTEM

UV8000

UV Reactor Chambers

UV8000 reactors are full penetration welded using 316L stainless steel. Welding is followed by pickling, passivation, mechanical and electro-polishing processes to ensure internally smooth, micro-inched, sanitary finishes. After final assembly, all UV8000 systems are integrity checked and hydrostatically tested.

Clean room manufacturing facilities ensure the quality of these UV products from our plant to your door.



316L reactor chamber finished to 15 Ra.

Control Panels & Electronic Circuitry

Trojan's understanding of installation limitations has led to flexibility in system designs. All UV8000 system control panels are mountable in remote locations and possess the latest in electronic circuitry and monitoring features. All panels come with a lockable front door, operator interface display, and electrical disconnect switch. The electrical systems are designed to UL standards and conform to CE directives.

On all low pressure lamp UV8000 systems, local, standard displays allow the operator to visibly view lamp operational status, total elapsed operating time and an optional UV intensity measurement at the system panel.

UV8000 medium pressure UV lamp systems are furnished with a microprocessor based control system. The microprocessor can be configured to provide specific control functions which permits the operation of the unit under such defined conditions as flowrate and UV dose delivery requirements. Individual units can also be tied to a central control system which can remotely monitor the UV system for status updates, alarm indication and redundant equipment availability.

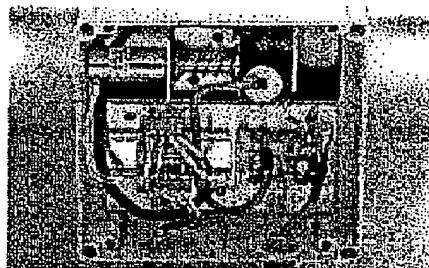
These standard features ensure the integrity required for reliable operation of your UV8000 system. Remote indication of alarm conditions can be obtained from a set of dry contacts on the circuitry of the UV8000 systems.

UV Intensity Monitoring

All Trojan low pressure lamp UV8000 systems can be equipped with a discrete UV intensity monitoring system which measures only UV energy emissions. The percent relative intensity is displayed on the control panel. All UV intensity and low UV alarm set-points are pre-set at the factory to provide proper indication of UV output during UV system operation and an alarm for times when inadequate levels of UV energy are being detected.

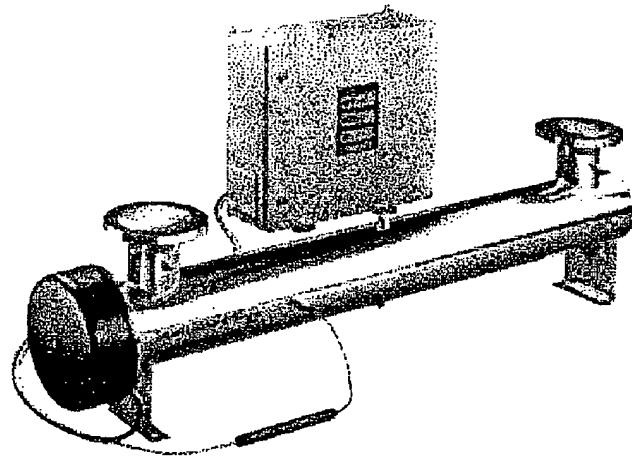
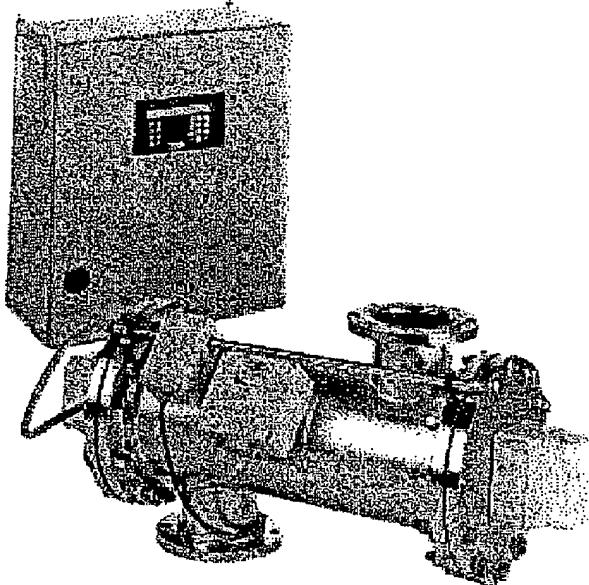
Medium pressure UV lamps emit the equivalent UV energy level of up to 16 low pressure UV lamps. As a result, UV intensity sensors must, from time to time, be recalibrated or replaced. In order to increase the life of the intensity sensor, Trojan has designed its sensor to obtain full UV intensity readings through a mechanical shutter

on a timed exposure basis. The frequency of the shutter activation is configured into the system controls when the medium pressure UV8000 system is installed. All UV8000 systems have a 4-20 mA signal for continuous remote monitoring of the relative UV intensity.



Medium pressure UV intensity monitor

TROJAN SYSTEM UV 8000



UV8000 Medium Pressure UV Lamp Systems

Trojan Model No.	Number of UV Lamps	Disinfection* Flowrate	TOC Reduction** Flowrate
UV01M20	1	500 GPM	185 GPM
UV01M30	2	1000 GPM	370 GPM
UV02M30	2	2000 GPM	650 GPM

* Based on a minimum UV transmission of 98% and a UV dose of 30,000 microwatt seconds/square centimetre being delivered at the end of lamp life (5,000 hours).

** Based on a minimum UV transmission of 98% and a UV dose of 90,000 microwatt seconds/square centimetre being delivered at the end of lamp life (5,000 hours).

UV8000 Low Pressure UV Lamp Systems

Trojan Model No.	Number of UV Lamps	Disinfection* Flowrate	TOC Reduction** Flowrate
8002S	2	25 GPM	8 GPM
8004S	4	50 GPM	15 GPM
8008S	8	85 GPM	28 GPM
8008S	8	120 GPM	40 GPM
8008L	8	240 GPM	80 GPM
8012L	12	360 GPM	120 GPM
8016L	16	480 GPM	160 GPM
8024L	24	720 GPM	240 GPM
8032L	32	960 GPM	320 GPM

* Based on a minimum UV transmission of 98% and a UV dose of 30,000 microwatt seconds/square centimetre being delivered at the end of lamp life (8,760 hours).

** Based on a minimum UV transmission of 98% and a UV dose of 90,000 microwatt seconds/square centimetre being delivered at the end of lamp life (8,760 hours).

Patents:

5,006,244 1,163,086 4,482,809 0,008,780B1
4,872,980 1,327,877 2,174,989 0,361,579B1

Other patents pending.

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Trojan ... the brightest ideas in UV technology



Trojan Technologies Inc.

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